TECHNICAL REPORT 4293

A
COMPUTER PROGRAM
THAT
COMPUTES AND DRAWS
an
EXACT OPERATING CHARACTERISTIC CURVE
USING THE
HYPERGEOMETRIC PROBABILITY DISTRIBUTION
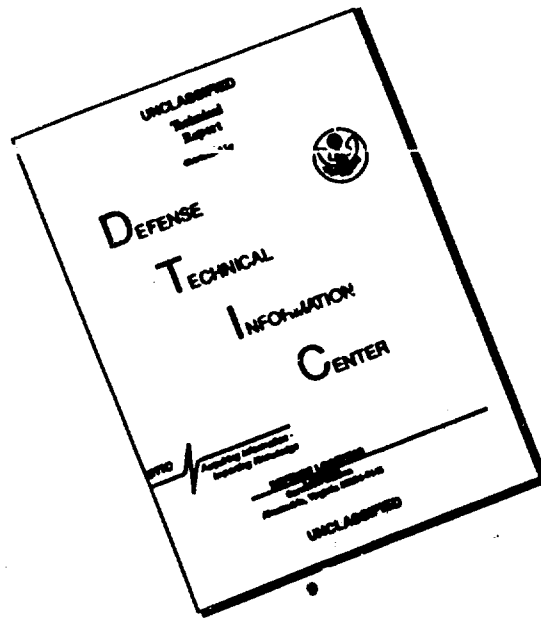
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NOVEMBER 1971

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13. ABSTRACT

A computer program was developed which uses the Hypergeometric Probability Distribution in computing and plotting percent defective vs. 10 important probability of acceptance points (.99, .975, .95, .90, .75, .50, .25, .10, .05 and .01).

DD FORM 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

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SUMMARY

A computer program was developed which uses the Hypergeometric Probability Distribution in computing and plotting percent defective vs. 10 important probability of acceptance points (.99, .975, .95, .90, .75, .50, .25, .10, .05 and .01).

DISCUSSION

An operating characteristic curve is a tool used in quality control for the purpose of buying or selling manufactured goods.

Using the formulae and solution as discussed in Reference 1 and altering the FORTRAN computer program described in that Reference, a new program was generated which computes and plots percent defective for 10 important probability of acceptance levels. Additional related information printed out is: defectives in original population, reliability, and confidence level.

Note: Since it is quite unusual that a sample will exceed 50% of the population, this condition has not been programmed. If it is desired to compute this, use the equalities as shown and discussed on page 4 of Reference 2.

FORTRAN PROGRAM

```
                PROGRAM ANNERO(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT   )
                DIMENSION G(60),BOPD (60),PAC(60),PACL(60),BOPL(60),PACCT(10),
                1PD(20),PA(20)
                DATA PACCT/.99,.975,.95,.90,.75,.5,.25,.10,.05,.01/
  5             WRITE (6,871)
                CALL PLOT (3,,3.,-3)
        400     READ (5,200) POP,SAMPLE,        DEF
        200     FORMAT(3F10.0)
                IF (POP) 399,399,243
 10     243     IF (SAMPLE - DEF)560,560,563
        560     WRITE (6,561) DEF,SAMPLE
        561     FORMAT (1H1,20(/),20X,*THE PROBABILITY OF OBTAINING *,F10.0,* DEFE
                1CTS OR LESS IN A SAMPLE OF*,F10.0,* IS*/20X,*ALWAYS 1 REGARDLESS
                2OF THE NUMBER OF INTERESTING ONES IN THE POPULATION.*)
 15             GO TO 400
        563     IF (SAMPLE - POP/2.)565,565,564
        564     WRITE (6,566) SAMPLE,POP
        566     FORMAT (1H1,20(/),20X,*NOW YOU HAVE DONE IT.  I TOLD YOU NOT TO EN
                1TER A SAMPLE SIZE GREATER*/20X,*THAN 1/2 OF THE POPULATION.  YOU E
 20             2NTERED A SAMPLE SIZE OF*,F10.0,* AND*/20X,* A POPULATION SIZE OF*,
                3F10.0,//20X,*IF YOU LIKE THIS PROGRAM, FAN MAIL WILL BE ACCEPTED.*
                4)
        565     WRITE (6,201)POP,SAMPLE,        DEF
        201     FORMAT (1H1,//50X,30HOPERATING CHARACTERISTIC CURVE.
 25             1 //25X,15HPOPULATION SIZE,                        F10.0,5X,6HSAMPLE,
                2F9.0,5X,18HACCEPTABLE DEFECTS,F6.0///26X13HIF DEFECTIVES,7X,7HPERC
                3ENT,5X,14HPROBABILITY OF,4X,11HRELIABILITY,5X,
                410HCONFIDENCE/27X,11HIN ORIGINAL,7X,9HDEFECTIVE,6X,10HACCEPTANCE,
                510X,2HIS,14X,2HIS/25X,14HPOPULATION ARE,
 30             610X,2HIS,13X,2HIS//)
                ICON = 1
        475     CONF = PACCT(ICON)
                AREA =   CONF - .5
                IF (AREA - .499 ) 477,476,476
 35     476     GUESS=((DEF + 4. )/ SAMPLE )  * POP
                IF (GUESS - POP - SAMPLE) 260,261,261
        261     GUESS = POP - 2. + DEF - SAMPLE
        260     CALL BACK (POP,SAMPLE,GUESS,DEF,REL,OTHERS,A,SUM,BAC,POPD)
                PAC(1) = BAC
 40             BOPD(1) = POPD
                GUESS =((DEF+2.)/SAMPLE) * POP
                CALL BACK (POP,SAMPLE,GUESS,DEF,REL,OTHERS,A,SUM,BAC,POPD)
                PAC(2) = BAC
                BOPD(2) = POPD
 45             IF ( BOPD(1) - BOPD(2)) 778,779,778
        779     GUESS = POPD - 4.
                CALL BACK (POP,SAMPLE,GUESS,DEF,REL,OTHERS,A,SUM,BAC,POPD)
                PAC(1) = BAC
                BOPD(1) = POPD
 50     778     DO 787  I = 3,20
                N = I +1
                G(I) =  BOPD (I-2) - (.5 - PAC(I-2) - AREA)/ ( PAC(I-1) - PAC(I-2)
                1)* (BOPD(I-2) - BOPD(I-1))
                IF (G(I) - DEF) 401,402,402
 55     401     GUESS = DEF + 2.
```

```
           GO TO 403
      402  GUESS = G(1)
      403  CALL MACK (POP,SAMPLE,GUESS,DEF,REL,OTHERS,A,SUM,BAC,POPD)
           BOPD(I) = POPD
 60        PAC (I) = BAC
           IF (ABS(BOPD(I) - BOPD(I-1)) - 3.)782,782,787
      787  CONTINUE
      782  IF (AREA - .5*PAC(N-1))207,206,206
      207  DO 208 I = N,90
 65        JEST = I
           IF (AREA - .5 * BAC) 211,691,691
      211  G(I) = G(I-1) - 1.
           GUESS = G(I)
           CALL MACK (POP,SAMPLE,GUESS ,DEF,REL,OTHERS,A,SUM,BAC,POPD)
 70        BOPD (I) = POPD
           PAC (I) = BAC
      208  CONTINUE
           GO TO 691
      206  DO 209 I = N,90
 75        IF (G(I-1)+1. - POP) 210,691,691
      210  G(I)= G(I-1)+1.
           JEST = I
           IF (AREA -.5 * BAC)691,247,247
      247  GUESS = G(I)
 80        CALL MACK (POP,SAMPLE,GUESS ,DEF,REL,OTHERS,A,SUM,BAC,POPD)
           BOPD (I) = POPD
           PAC (I) = BAC
      209  CONTINUE
           GO TO 691
 85   240  WRITE (6,241) POP
           PO (20)(CON)     = 100.
           PA (20)(CON)     = 0.0
      241  FORMAT (87X,F10.0,1VX,8H100.00,1VX,8H1.000000,VX,8H   .00,1VX,8H1.000
           1000)
 90        GO TO 800
      477  GUESS = (( DEF - 4.) /SAMPLE ) * POP
           IF (GUESS - DEF - 1. ) 360,360,361
      360  GUESS = DEF + 1.
      361  CALL MACK (POP,SAMPLE,GUESS,DEF,REL,OTHERS,A,SUM,BAC,POPD)
 95        BOPL(1) = POPD
           PACL(1)= BAC
           GUESS = ((DEF - .1) /SAMPLE ) * POP
           IF (GUESS - BOPL(1) -0.5)362,362,363
      362  GUESS =(DEF/SAMPLE ) * POP + 5.
 100  363  CALL MACK (POP,SAMPLE,GUESS,DEF,REL,OTHERS,A,SUM,BAC,POPD)
           BOPL(2) = POPD
           PACL(2)= BAC
           IF (   (BOPL(1) - BOPL(2))      ) 370,370,370
      370  GUESS = POPD + 4.
 105       CALL MACK (POP,SAMPLE,GUESS,DEF,REL,OTHERS,A,SUM,BAC,POPD)
           PACL(2) = BAC
           BOPL(2) =POPD
      370  DO 387 I = 3,20
           N = I +1
 110       G(I) = BOPL(I-2) + (PACL(I-2) - .5  -AREA)/(PACL(I - 2) - PACL(I-1)
```

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```
          IF (G(2))791,791,792
  791     G(I) = 0.
  792     GUESS = G(I)
          CALL BACK (POP,SAMPLE,GUESS,DEF,REL,OTHERS,A,SUM,BAC,POPD)
          BOPL(I) = POPD
          PACL(I) = BAC
          IF (ABS(BOPL(I) - BOPL(I-1)) - 3.)382,382,307
  307     CONTINUE
  382     IF (PACL(N-1)-.5 - AREA)307,307,300
  307     DO 300 I = N,50
          JEST =I
          IF (BAC - .5 - AREA)320,320,400
  320     G(I) = G(I-1) - 1.
          GUESS = G(I)
          IF (GUESS) 82,84,84
  82      GUESS = -1.0
  84      CALL BACK (POP,SAMPLE,GUESS,DEF,REL,OTHERS,A,SUM,BAC,POPD)
          PACL (I) = BAC
          BOPL (I) = POPD
  300     CONTINUE
          GO TO 494
  306     DO 309 I = N,50
          JEST =I
  310     IF (BAC - .5 - AREA)494,310,310
          G(I) = G(I-1) + 1.
          GUESS = G(I)
          CALL BACK (POP,SAMPLE,GUESS,DEF,REL,OTHERS,A,SUM,BAC,POPD)
          PACL (I) = BAC
          BOPL (I) = POPD
  309     CONTINUE
          GO TO 494
  491     POPDA = BOPD(JEST - 1)
          POPDB = BOPD(JEST - 2)
          PACA  = PAC(JEST - 1)
          PACB  = PAC(JEST - 2)
          IF (POPDA - POPD)492,492,493
  494     POPDA = BOPL(JEST-1)
          POPDB = BOPL(JEST - 2)
          PACA  = PACL (JEST-1)
          PACB  = PACL (JEST - 2)
          GO TO 495
  493     PCTD = POPDB/POP  * 100.
          REL  = 100. - PCTD
          SUM  = 1. - PACB
          PA (2* ICON - 1 )= PACB
          PD (2* ICON - 1 )= PCTD
          WRITE (6,959)POPDB,PCTD,PACB,REL,SUM
          IF (POPDA - POP)431,300,300
  431     PCTD = POPDA/POP * 100.
          REL  = 100. - PCTD
          SUM  = 1. - PACA
          PD (2*ICON)      = PCTD
          PA (2*ICON)      = PACA
          WRITE (6,959)POPDA,PCTD,PACA,REL,SUM
```

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```
                    GO TO 475
            492     POPOC = XPOA
                    PHCC
                    POPL
            170     PHCH =
                    POPOB = POPOC
                    PHCC = PHCC
                    GO TO 403
            475     WRITE 101(001)
            175     480     FORMAT (/)
                    ICON = 3 = ICON
                    IF (ICON - 11) 475,800,800
            800     ICON = ICON + 2
                    CALL SCALE     (PB,ICON,1,10,0,0,0,10,,1)
            180     CALL SCALE     (PB,ICON,12,10,000,000,101)
                    CALL AXIS  (0.0,0.0,17HPERCENT DEFECTIVE,17,10,0,0,0,0,0,10.)
                    CALL AXIS  (0.0,0.0,21HPROBABILITY OF ACCEPTANCE,21,10,90,90,0,0,00
                    10.1)
                    CALL LINE  (PB,PHY,ICON,1,100,1000)
            185     CALL SYMBOL (5,0,10,0,27HQ, C, CURVE  HYPERGEOMETRIC,27,,14,0,0)
                    CALL SYMBOL (5,0, 7,0,10HPOPULATION,10,1000,0)
                    CALL NUMBER (7.0,9.50,POP,0,,16,0,0)
                    CALL SYMBOL (5,0, 9,0, 6HSAMPLE,6,1000,0)
            190     CALL NUMBER (7.0, 9.0,SAMPLE,0,,15,0,0)
                    CALL SYMBOL (5,0, 8,0,10HDEFECTIVES,10,1000,0)
                    CALL NUMBER (7.0, 8.50,DEF,0,,14,0,0)
                    CALL PLOT  (13.0,0.0,-3)
                    GO TO 400
            195     871     FORMAT (1H1,20(/),30H1THE AUTHOR, MR. D NAPPAPORT, IS ONLY RESPON
                    1SIBLE FOR ALL MISTAKES.)
            490     FORMAT (87X,F5.0,9XF5.0,9XF5.0, 9XF5.0,9XF5.0)
            200     STOP
                    END
```

```
SUBROUTINE  BACK       TRACE                    CDC 6600 FTN V3.0-P201 OPT=1  11/09/71  13.37.25.

                      SUBROUTINE BACK (POP,SAMPLE,GUESS,DEF,REL,OTHERS,A,SUM,BAC,POPD)
            102    IGLOO = GUESS
                   POPD = IGLOO + 1
            103    IF (POP - POPD)116,116,117
            116    IGLOO = .0999 + POP
                   POPD = IGLOO
                   IF (POP - POPD - SAMPLE)130,117,117
            130    IGLOO = POP - SAMPLE + DEF + .1
                   POPD = IGLOO
 10         117    CONTINUE
                   W = DEF
                   IF (POPD -POP/2.)119,119,111
            119    X= POPD
                   Y = SAMPLE
 15                Z = POP
            118    BAC  = ANNE (Z,Y,X,W)
                   REL  = (1. -(POPD/POP)) * 100.
                   OTHERS =  POP - POPD
                   A = 100. - REL
 20                SUM = 1. -  BAC
                   RETURN
            111    W = SAMPLE -    W - 1.
                   X = POP - POPD
                   Y = SAMPLE
 25                Z = POP
                   SUM =  ANNE (Z,Y,X,W)
                   REL  = (1. - (POPD/POP))* 100.
                   A   = 100. - REL
                   BAC = 1. - SUM
 30                OTHERS = POP - POPD
                   RETURN
                   END
```

                                                                              9

```
              FUNCTION ANNE (HILARY,RAY,DIANE,DEF)
              II = DEF + .1
       17     IF (RAY - DIANE) 10,10,11
       10     MOE = RAY + 1.1
              GO TO 15
       11     MOE = DIANE + 1.1
              GO TO 15
       15     FLO = 0.0
              JOYCE = 1
              LENNY = 0
              CLARA=1.
              SYDELL = HILARY - DIANE
              XLAURA = HILARY - RAY
              XMARC = SYDELL - RAY
       19     IF (XLAURA - SYDELL) 1,1,2
       2      BEN = XLAURA
              TOBY = SYDELL
              GO TO 3
       1      BEN = SYDELL
              TOBY = XLAURA
       3      JOSS= HILARY - BEN + .1
              HERB = 0.0
       25     IF ( JOYCE - JOSS) 22,22,4
       22     CONTINUE
              HERB = ALOG10 ( TOBY/HILARY ) + HERB
              TOBY = TOBY - 1.
              HILARY = HILARY - 1.
              JOYCE = JOYCE + 1
              GO TO 25
       4      CONTINUE
              GO TO 19 IF MOE = 17 MOE
              IF (HERB + 90.) 8,8,20
       20     FLO = FLO + ( 10. ** HERB)
       21     TRUDY = 1. - FLO
       5      SAM = 10. ** HERB
              IF (II - LENNY) 23,23,8
       8      LENNY = LENNY + 1
              HERB = HERB + ALOG10 ((RAY*DIANE)/((XMARC + 1.)* CLARA))
              CLARA = CLARA + 1.
              XMARC = XMARC + 1.
              DIANE = DIANE + 1.
              RAY = RAY - 1.
       16     CONTINUE
       23     ANNE = FLO
              RETURN
              END
```

REFERENCES

1. Donald C. Rappaport, A Computer Program for Exact Reliability and Confidence Using the Hypergeometric Probability Distribution, Picatinny Arsenal Technical Report 4181, January 1971.

2. G. J. Lieberman and D. B. Owen, Tables of the Hypergeometric Probability Distribution, Stanford University Press, Stanford, California, 1961.

APPENDIX A

Input

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INPUT

F - format

Column Numbers	Input	Format
1-10	Population	F 10.0
11-20	Sample	F 10.0
21-30	Defectives	F 10.0

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APPENDIX B

Sample Output

14a

OPERATING CHARACTERISTIC CURVE

POPULATION SIZE   50.   SAMPLE   10.   ACCEPTABLE DEFECTS   1.

IF DEFECTIVES IN ORIGINAL POPULATION ARE	PERCENT DEFECTIVE IS	PROBABILITY OF ACCEPTANCE IS	RELIABILITY IS	CONFIDENCE IS
1.	2.00	1.000000	98.00	.000000
2.	4.00	.963265	96.00	.036735
1.	2.00	1.000000	98.00	.000000
2.	4.00	.963265	96.00	.036735
2.	4.00	.963265	96.00	.036735
3.	6.00	.902041	94.00	.097959
3.	6.00	.902041	94.00	.097959
4.	8.00	.825836	92.00	.174164
4.	8.00	.825836	92.00	.174164
5.	10.00	.741900	90.00	.258100
7.	14.00	.570934	86.00	.429066
8.	16.00	.490502	84.00	.509498
11.	22.00	.288817	78.00	.711183
12.	24.00	.236449	76.00	.763551
15.	30.00	.120975	70.00	.879025
16.	32.00	.094463	68.00	.905537
18.	36.00	.055430	64.00	.944570
19.	38.00	.041607	62.00	.958393
23.	46.00	.011315	54.00	.988685
24.	48.00	.007817	52.00	.992183

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OPERATING CHARACTERISTIC CURVE

POPULATION SIZE   12345.   SAMPLE   456.   ACCEPTABLE DEFECTS   12.

IF DEFECTIVES IN ORIGINAL POPULATION ARE	PERCENT DEFECTIVE IS	PROBABILITY OF ACCEPTANCE IS	RELIABILITY IS	CONFIDENCE IS
169.	1.37	.990082	98.63	.009918
170.	1.38	.989609	98.62	.010391
191.	1.55	.975010	98.45	.024990
192.	1.56	.974058	98.44	.025942
211.	1.71	.950528	98.29	.049472
212.	1.72	.948980	98.28	.051020
236.	1.91	.901517	98.09	.098483
237.	1.92	.899096	98.08	.100904
283.	2.29	.751692	97.71	.248308
284.	2.30	.747811	97.70	.252189
342.	2.77	.501683	97.23	.498317
343.	2.78	.497393	97.22	.502607
408.	3.30	.252853	96.70	.747147
409.	3.31	.249799	96.69	.750201
475.	3.85	.100760	96.15	.899240
476.	3.86	.099233	96.14	.900767
518.	4.20	.050349	95.80	.949651
519.	4.20	.049500	95.80	.950500
605.	4.90	.010041	95.10	.989959
606.	4.91	.009842	95.09	.990158

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17